PB-250 474

LAKE JUNALUSKA, HAYWOOD COUNTY, NORTH CAROLINA

National Environmental Research Center

Prepared for:

Pacific Northwest Environmental Research Laboratory

June 1975

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NATIONAL EUTROPHICATION SURVEY

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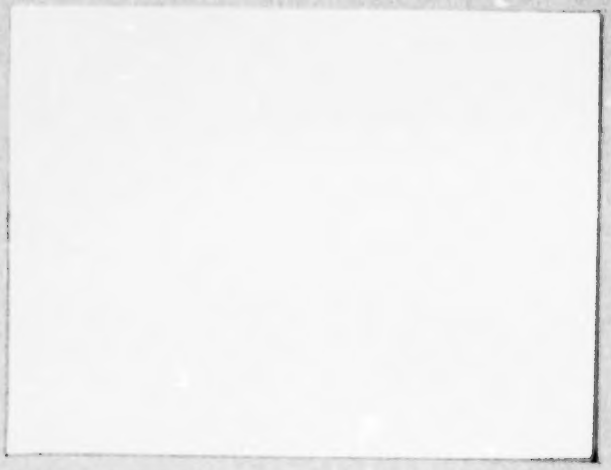

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REPORT
ON
LAKE JUNALUSKA
HAYWOOD COUNTY
NORTH CAROLINA
EPA REGION IV
WORKING PAPER No. 384

WITH THE COOPERATION OF THE
NORTH CAROLINA DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES
AND THE
NORTH CAROLINA NATIONAL GUARD
JUNE, 1975

TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Lake Junaluska, Haywood County, North Carolina		5. REPORT DATE Prepared June 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 384
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

PRICES SUBJECT TO CHANGE

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		37
	20. SECURITY CLASS *(This page)*	22. PRICE
		$4.00

EPA Form 2220-1 (9-73)

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Carolina Department of Natural and Economic Resources for professional involvement and to the North Carolina National Guard for conducting the tributary sampling phase of the Survey.

Lewis R. Martin, Director of the Division of Environmental Management; Darwin L. Coburn, Chief of the Water Quality Section; and Julian R. Taylor, Supervisor of the Monitoring Program Unit; provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

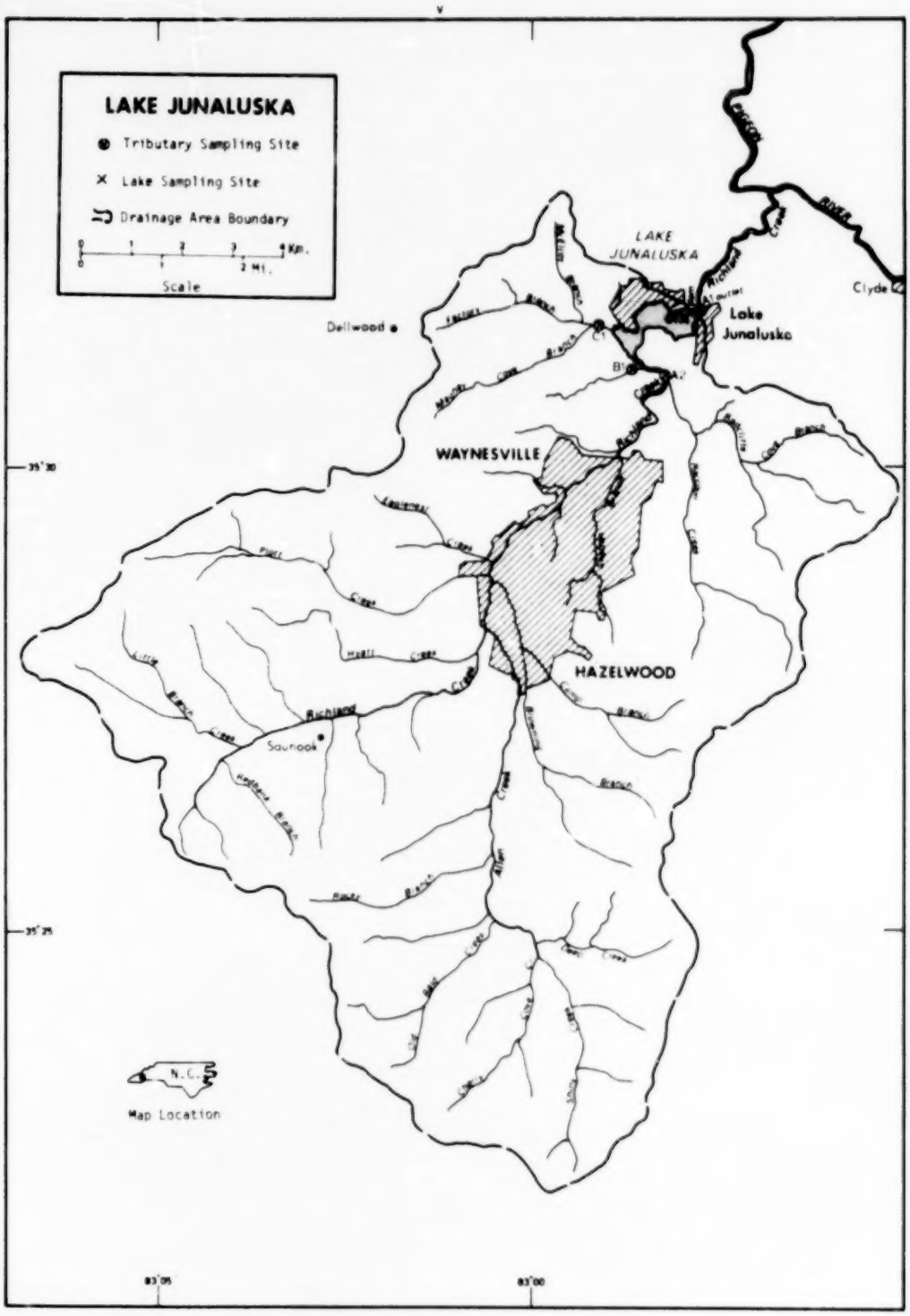
Major General William M. Buck, formerly Adjutant General of North Carolina, and Project Officer Colonel Arthur J. Bouchard, who directed the volunteer efforts of the North Carolina National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF NORTH CAROLINA

LAKE NAME	COUNTY
Badin	Montgomery, Stanly
Blewett Falls	Anson, Richmond
Chatuge	Clay, NC; Towns, GA
Fontana	Graham, Swain
Hickory	Alexander, Caldwell, Catawba
High Rock	Davidson, Rowan
Hiwassee	Cherokee
James	Burke, McDowell
John H. Kerr (Nut Bush Creek)	Granville, Vance, Warren, NC; Halifax, Mecklenburg, VA
Junaluska	Haywood
Lookout Shoals	Alexander, Catawba, Iredell
Mountain Island	Gaston, Mecklenburg
Norman	Catawba, Iredell, Lincoln, Mecklenburg
Rhodhiss	Burke, Caldwell
Santeetlah	Graham
Tillery	Montgomery, Stanly
Waccamaw	Columbus
Waterville	Haywood
Wylie	Gaston, Mecklenburg, NC; York, SC


LAKE JUNALUSKA
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Scale
LAKE JUNALUSKA
Lake Junaluska
Clyde
Dellwood
WAYNESVILLE
HAZELWOOD
Saunook
N.C.
Map Location
35°30
35°25
83°05
83°00

LAKE JUNALUSKA

STORET NO. 3709

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Junaluska is eutrophic. However, because this water body has a mean hydraulic retention time of only 13 days, it more closely resembles a slow-moving stream; and the term "over-enriched" may be a more appropriate description of the lake condition. Lake Junaluska ranked twelfth in overall trophic quality when the 16 North Carolina lakes sampled in 1973 were compared using a combination of six parameters*. Eight of the lakes had less median total phosphorus, ten had less median dissolved phosphorus, 11 had less median inorganic nitrogen, 12 had less mean chlorophyll a, and eight had greater and one had the same mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred in July and September.

Survey limnologists did not observe rooted aquatic vegetation or algal concentrations; however, a 10-fold increase in chlorophyll a and a significant increase in the number of phytoplankton occurred in September (see pages 7 and 8).

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* See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Junaluska was phosphorus limited at the time the assay sample was collected (03/24/73). These results are substantiated by the lake data; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 28 to 1 or greater at all sampling times.

C. Nutrient Controllability:

1. Point sources--There were no known point sources contributing phosphorus to Lake Junaluska during the sampling year, although the existing phosphorus loading rate of 6.38 $g/m^2/yr$ is over 2.5 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic rate (see page 12). However, the lake has a rather short hydraulic retention time of 13 days, and Vollenweider's model may not be applicable. Nonetheless, the trophic condition of the lake is evidence of excessive nutrient loads.

There was an apparent loss of phosphorus from Lake Junaluska during the sampling year (see page 10). It is likely that much of the loss can be attributed to the hydraulic dredging of the lake in October, 1973 (Cook, 1975), about midway through the Survey tributary sampling year. It would be expected that dredging would increase the rate of solubilization of previously

sedimented phosphorus through agitation and resuspension of the bottom sediments and thus would result in an unmeasured internal phosphorus load. Also, part of the loss may have resulted from unmeasured phosphorus contributed directly to the lake in drainage from the lakeshore urban areas.

The nitrogen loss during the sampling year probably occurred in the same way as the phosphorus loss.

2. Non-point sources--The phosphorus input from non-point sources accounted for the entire load impacting Lake Junaluska. Richland Creek contributed 89.9%, the Unnamed Creek (B-1) contributed 1.0%, and Factory Branch contributed 8.4% of the total phosphorus input. Ungaged tributaries were estimated to have contributed 0.4% of the total.

The phosphorus export rate of Factory Branch, 39 $kg/km^2/yr$, is somewhat higher than the rates of the other tributaries in the Lake Junaluska drainage basin (see page 11). This may be indicative of unsampled point sources in the drainage but could result from underestimation of the drainage area of the stream.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.81 kilometers^2.
2. Mean depth: 5.6 meters.
3. Maximum depth: >7.0 meters.
4. Volume: 4.5×10^6 m^3.
5. Mean hydraulic retention time: 13 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Richland Creek	150.2	3.7
Unnamed Creek (B-1)	1.8	0.1
Factory Branch	11.2	0.3
Minor tributaries & immediate drainage -	0.7	<0.1
Totals	163.9	4.1

2. Outlet -

Richland Creek	164.7**	4.1

C. Precipitation***:

1. Year of sampling: 146.1 centimeters.
2. Mean annual: 116.6 centimeters.

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† Table of metric conversions--Appendix B.
†† Park, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Junaluska was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at a single station on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was collected for phytoplankton identification and enumeration; and a similar sample was collected for chlorophyll a analysis. During the first visit, a single 18.9-liter depth-integrated sample was taken for algal assays. The maximum depth sampled was 7.0 meters.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE JONALUSKA
STORET CODE 3709

PARAMETER	1ST SAMPLING (3/24/73) 1 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/ 5/73) 1 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/20/73) 1 SITES RANGE	MEAN	MEDIAN
TEMP (C)	8.7 - 10.2	9.2	8.9	19.4 - 24.1	21.8	21.6	19.6 - 21.2	20.5	20.6
DISS OXY (MG/L)	9.4 - 10.0	9.8	10.0	3.2 - 8.0	5.2	4.5	0.8 - 2.0	1.5	1.4
CNDCTVY (MCROMO)	70. - 75.	71.	70.	105. - 125.	113.	110.	102. - 110.	106.	107.
PH (STAND UNITS)	7.3 - 7.8	7.5	7.5	6.7 - 7.3	7.0	6.9	6.3 - 6.5	6.4	6.4
TOT ALK (MG/L)	11. - 12.	12.	12.	15. - 17.	16.	17.	18. - 22.	20.	21.
TOT P (MG/L)	0.040 - 0.055	0.046	0.042	0.020 - 0.031	0.024	0.023	0.028 - 0.047	0.035	0.029
ORTHO P (MG/L)	0.007 - 0.009	0.008	0.007	0.007 - 0.011	0.009	0.009	0.012 - 0.016	0.013	0.012
NO2+NO3 (MG/L)	0.640 - 0.700	0.675	0.680	0.320 - 0.360	0.340	0.340	0.110 - 0.140	0.120	0.110
AMMONIA (MG/L)	0.110 - 0.140	0.132	0.120	0.090 - 0.280	0.182	0.180	0.080 - 0.390	0.250	0.280
KJEL N (MG/L)	0.200 - 0.300	0.275	0.300	0.200 - 0.400	0.350	0.400	0.800 - 1.000	0.900	0.900
INORG N (MG/L)	0.800 - 0.820	0.807	0.805	0.420 - 0.600	0.522	0.535	0.190 - 0.500	0.370	0.420
TOTAL N (MG/L)	0.840 - 1.000	0.950	0.960	0.530 - 0.760	0.690	0.735	0.910 - 1.110	1.020	1.040
CHLRPYL A (UG/L)	0.5 - 0.5	0.5	0.5	2.0 - 2.0	2.0	2.0	19.2 - 19.2	19.2	19.2
SECCHI (METERS)	0.6 - 0.6	0.6	0.6	1.1 - 1.1	1.1	1.1	1.2 - 1.2	1.2	1.2

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal units per ml
03/24/73	1. Flagellates	850
	2. Lyngbya	50
	3. Cymbella	36
	4. Nitzschia	23
	5. Achnanthes	14
	Other genera	62
	Total	1,035
07/05/73	1. Gloeocystis	408
	2. Dinobryon	82
	3. Unidentified cysts	82
	4. Pennate diatoms	72
	5. Synedra	63
	Other genera	153
	Total	860
09/20/73	1. Gloeocystis	3,023
	2. Aphanizomenon	1,626
	3. Flagellates	737
	4. Cryptomonas	127
	5. Microcystis	127
	Other genera	379
	Total	6,019

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/24/73	01	0.5
07/05/73	01	2.0
09/20/73	01	19.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.016	0.824	3.4
0.050 P	0.066	0.824	19.7
0.050 P + 1.0 N	0.066	1.824	24.9
1.0 N	0.016	1.824	3.9

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Junaluska was moderately high at the time the sample was taken (03/24/73). Also, the six-fold increase in yield with the addition of phosphorus indicates that the lake was limited by phosphrous at that time. Note that the addition of only nitrogen produced a yield not significantly different than the control yield.

The lake data further substantiate phosphorus limitation; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 28 to 1 or greater at all sampling times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the North Carolina National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for high runoff months when two samples were collected. Sampling was begun in March, 1973, and was completed in February, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Carolina District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at station B-1 and multiplying the means by the ZZ area in km^2.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Industrial - Unknown

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Richland Creek	4,645	89.9
Unnamed Creek (B-1)	50	1.0
Factory Branch	435	8.4
b. Minor tributaries & immediate drainage (non-point load) -	20	0.4
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Industrial - Unknown	-	-
f. Direct precipitation* -	15	0.3
Total	5,165	100.0

2. Outputs -

Lake outlet - Richland Creek	5,740

3. Net annual P loss - 575 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Richland Creek	105,460	86.0
Unnamed Creek (B-1)	2,535	2.1
Factory Branch	12,800	10.4
b. Minor tributaries & immediate drainage (non-point load) -	985	0.8
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Industrial - Unknown	-	-
f. Direct precipitation* -	875	0.7
Total	122,655	100.0

2. Outputs -

Lake outlet - Richland Creek 140,225

3. Net annual N loss - 17,570 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Richland Creek	31	702
Unnamed Creek (B-1)	28	1,408
Factory Branch	39	1,143

* See Working Paper No. 175.

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	6.38	loss*	151.4	loss*

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Junaluska:

"Dangerous" (eutrophic rate)	2.40
"Permissible" (oligotrophic rate)	1.20

* There appeared to be significant losses of both nitrogen and phosphorus from Lake Junaluska. This would not be expected to occur (particularly in the case of the phosphorus loss) even in a lake with a hydraulic retention time of only 13 days. It is likely that these losses were the result of dredging of the lake and unmeasured nutrient inputs in urban drainage (see pages 2 and 3).

V. LITERATURE REVIEWED

Cook, Grover, 1975. Personal communication (dredging and urban drainage). NC Dept. of Nat. and Econ. Resources, Raleigh.

Park, David, 1974. Personal communication (lake morphometry). NC Dept. of Nat. and Econ. Resources, Raleigh.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3719	LAKE WACCAMAW	534
2	3716	SANTEELAH LAKE	446
3	3711	MOUNTAIN ISLAND LAKE	419
4	3707	HIWASSEE LAKE	414
5	3704	FONTANA LAKE	392
6	3713	LAKE NORMAN	346
7	3708	LAKE JAMES	334
8	3710	LOOKOUT SHOALS	327
9	3715	RHODHISS LAKE	296
10	3705	LAKE HICKORY	283
11	3717	LAKE TILLERY	246
12	3709	LAKE JUNALUSKA	220
13	3702	BLEWETT FALLS LAKE	200
14	3718	WATERVILLE RESERVOIR	140
15	3701	BADIN LAKE	124
16	3706	HIGH ROCK LAKE	76

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3701	BADIN LAKE	33 (5)	7 (1)	27 (4)	27 (4)	3 (0)	27 (4)	124
3702	BLEWETT FALLS LAKE	7 (1)	13 (2)	7 (1)	73 (11)	93 (14)	7 (1)	200
3704	FONTANA LAKE	100 (15)	33 (5)	93 (14)	100 (15)	3 (0)	63 (9)	392
3705	LAKE HICKORY	27 (4)	60 (9)	53 (8)	13 (2)	80 (12)	50 (7)	283
3706	HIGH ROCK LAKE	13 (2)	20 (3)	0 (0)	0 (0)	23 (2)	20 (3)	76
3707	HIWASSEE LAKE	87 (13)	80 (12)	87 (13)	47 (7)	50 (7)	63 (9)	414
3708	LAKE JAMES	60 (9)	87 (13)	80 (12)	7 (1)	23 (2)	77 (11)	334
3709	LAKE JUNALUSKA	47 (7)	27 (4)	43 (6)	20 (3)	50 (7)	33 (5)	220
3710	LOOKOUT SHOALS	53 (8)	47 (7)	60 (9)	67 (10)	60 (9)	40 (6)	327
3711	MOUNTAIN ISLAND LAKE	73 (11)	73 (11)	43 (6)	53 (8)	87 (13)	90 (13)	419
3713	LAKE NORMAN	67 (10)	53 (8)	73 (11)	40 (6)	23 (2)	90 (13)	346
3715	RHODHISS LAKE	20 (3)	67 (10)	33 (5)	93 (14)	70 (10)	13 (2)	296
3716	SANTEELAH LAKE	93 (14)	93 (14)	100 (15)	60 (9)	23 (2)	77 (11)	446
3717	LAKE TILLERY	40 (6)	40 (6)	13 (2)	33 (5)	70 (10)	50 (7)	246
3718	WATERVILLE RESERVOIR	0 (0)	0 (0)	20 (3)	80 (12)	40 (6)	0 (0)	140
3719	LAKE WACCAMAW	80 (12)	100 (15)	67 (10)	87 (13)	100 (15)	100 (15)	534

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3701	BADIN LAKE	0.042	0.680	466.750	7.190	14.900	0.012
3702	BLEWETT FALLS LAKE	0.090	0.655	476.889	4.167	10.800	0.034
3704	FONTANA LAKE	0.011	0.550	392.650	3.438	14.900	0.007
3705	LAKE HICKORY	0.047	0.320	461.000	7.275	13.400	0.008
3706	HIGH ROCK LAKE	0.090	0.580	477.454	14.283	14.800	0.017
3707	HIWASSEE LAKE	0.015	0.240	420.555	5.678	14.200	0.007
3708	LAKE JAMES	0.020	0.160	428.866	7.660	14.800	0.006
3709	LAKE JUNALUSKA	0.031	0.560	462.000	7.233	14.200	0.009
3710	LOOKOUT SHOALS	0.026	0.370	459.167	4.200	13.800	0.008
3711	MOUNTAIN ISLAND LAKE	0.018	0.270	462.000	5.580	12.800	0.005
3713	LAKE NORMAN	0.019	0.330	446.667	5.807	14.800	0.005
3715	RHODHISS LAKE	0.061	0.305	462.111	3.578	13.600	0.019
3716	SANTEELAH LAKE	0.011	0.160	366.400	5.360	14.800	0.006
3717	LAKE TILLERY	0.040	0.470	468.600	6.827	13.600	0.008
3718	WATERVILLE RESERVOIR	0.103	0.860	468.333	3.817	14.400	0.041
3719	LAKE WACCAMAW	0.018	0.120	455.667	3.583	9.800	0.004

APPENDIX B

CONVERSIONS FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 1/10/75

LAKE CODE 3709 LAKE JUNALUSKA

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 164.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3709A1	164.7	5.38	6.57	7.08	6.29	4.30	3.34	2.58	2.44	2.10	2.49	2.80	4.13	4.11
3709A2	150.2	4.90	5.97	6.46	5.72	3.91	3.03	2.35	2.21	1.90	2.27	2.55	3.77	3.74
3709B1	1.8	0.05	0.07	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.03	0.03	0.05	0.05
3709C1	11.2	0.37	0.45	0.48	0.42	0.28	0.22	0.18	0.16	0.14	0.17	0.19	0.28	0.28
3709Z7	1.5	0.05	0.06	0.06	0.06	0.04	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.04

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 164.7
SUM OF SUB-DRAINAGE AREAS = 164.7

TOTAL FLOW IN = 49.37
TOTAL FLOW OUT = 49.50

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3709A1	3	73	12.46	25	8.07				
	4	73	5.95	15	4.53				
	5	73	6.65	13	5.10	27	4.67		
	6	73	4.67						
	7	73	2.69	1	3.11	29	2.80		
	8	73	2.12	12	3.26				
	9	73	1.42						
	10	73	1.27	14	1.36				
	11	73	2.55	10	1.19				
	12	73	7.22	9	4.25				
	1	74	11.04	6	13.03	20	5.38		
	2	74	9.34	10	7.50	24	10.76		
3709A2	3	73	11.47	25	7.65				
	4	73	5.52	15	4.25				
	5	73	6.23	13	4.81	27	4.53		
	6	73	4.39						
	7	73	2.55	1	2.97	29	2.38		
	8	73	1.98	12	2.27				
	9	73	1.42						
	10	73	1.27	14	1.13				
	11	73	2.41	10	1.08				
	12	73	6.80	9	3.96				
	1	74	10.19	6	11.89	20	4.96		
	2	74	8.78	10	6.80	24	9.91		

TRIBUTARY FLOW INFORMATION FOR NORTH CAROLINA 1/10/75

LAKE CODE 3709 LAKE JUNALUSKA

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
370981	3	73	0.13	25	0.08				
	4	73	0.06	15	0.05				
	5	73	0.06	13	0.05	27	0.04		
	6	73	0.05						
	7	73	0.03	1	0.04	29	0.03		
	8	73	0.03	12	0.04				
	9	73	0.02						
	10	73	0.01	14	0.01				
	11	73	0.03	10	0.01				
	12	73	0.04	9	0.05				
	1	74	0.14	6	0.15	20	0.06		
	2	74	0.12	10	0.08	24	0.12		
370901	3	73	0.42	25	0.44				
	4	73	0.37	15	0.31				
	5	73	0.40	13	0.34	27	0.25		
	6	73	0.31						
	7	73	0.20	1	0.24	29	0.19		
	8	73	0.18	12	0.23				
	9	73	0.13						
	10	73	0.10	14	0.09				
	11	73	0.18	10	0.09				
	12	73	0.48	9	0.31				
	1	74	0.85	6	1.10	20	0.42		
	2	74	0.71	10	0.68	24	0.74		
370977	3	73	0.11						
	4	73	0.05						
	5	73	0.05						
	6	73	0.04						
	7	73	0.03						
	8	73	0.02						
	9	73	0.02						
	10	73	0.01						
	11	73	0.02						
	12	73	0.06						
	1	74	0.12						
	2	74	0.09						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/07

370901
35 41 33.0 082 57 58.0
LAKE JUNALUSKA
37087 NORTH CAROLINA

11FMALES
1 2111202
0023 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00403 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/03/24	12 30	0000	10.2		24	76	7.50	12	0.110	0.300	0.700	0.009
	12 30	0003	9.1	10.0		70	7.60	12	0.120	0.200K	0.680	0.007
	12 30	0015	8.8	10.0		70	7.50	11	0.120	0.300	0.680	0.008
	12 30	0023	8.7	9.4		75	7.30	11	0.140	0.300	0.640	0.007
73/07/05	13 00	0000	24.1		44	125	7.30	15	0.160	0.400	0.350	0.011
	13 00	0004	23.0	8.0		112	7.10	16	0.040	0.200K	0.330	0.010
	13 00	0011	20.8	4.5		108	6.80	17	0.200	0.400	0.360	0.007
	13 00	0019	19.8	3.2		105	6.70	17	0.280	0.400	0.320	0.009
73/09/20	13 10	0000	21.2	1.4	48	107	6.40	18	0.080	0.800	0.110	0.012
	13 10	0010	20.6	2.0		110	6.30	21	0.280	0.900	0.140	0.016
	13 10	0020	19.6	0.8		102	6.50	22	0.340	1.000	0.110	0.012

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/01/07

370901
35 31 33.0 082 57 58.0
LAKE JUNALUSKA
37087 NORTH CAROLINA

11EPALES 2111202
3 0023 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/03/24	12 30	0000	0.041	5.5
	12 30	0009	0.040	
	12 30	0015	0.043	
	12 30	0023	0.055	
73/07/05	13 00	0000	0.025	2.0
	13 00	0004	0.022	
	13 00	0011	0.020	
	13 00	0019	0.031	
73/09/20	13 10	0000	0.028	14.2
	13 10	0010	0.029	
	13 10	0020	0.047	

APPENDIX E

TRIBUTARY DATA

3709A1 LS3709A1
35 31 30.0 083 58 00.0
RICHLAND CREEK
37023 7.5 CLYDE
0/LAKE JUNALUSKA
30 MROG 400 FT HELO DAM-LAKE JUNALUSKA
11E-ALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	10	15	0.600	0.250	0.091	0.006	0.035
73/04/15	11	26	0.480	0.460	0.210	0.007	0.060
73/05/13	09	25	0.231	0.330	0.025	0.006	0.030
73/05/27	09	15	0.160	0.790	0.025	0.014	0.030
73/07/07	10	25	0.231	0.400	0.044	0.006	0.025
73/07/29	09	00	0.198	1.470	0.080	0.006	0.045
73/10/14	02	00	0.170	1.550	0.110	0.008	0.035
73/11/10	16	00	0.200	0.450	0.112	0.005K	0.025
73/12/09	09	00	0.670	0.600	0.110	0.012	0.077
74/01/06	09	15	0.704	0.300	0.060	0.016	0.065
74/01/20	08	45	0.560	0.600	0.056	0.008	0.030
74/02/10	09	10	0.550	1.000	0.095	0.010	0.070
74/02/24	08	40	0.490	0.500	0.065	0.010	

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/01/14

3709A2 LS3709A2
35 31 30.0 083 58 00.0
RICHLAND CREEK
37 7.5 CLYDE
1/LAKE JUNALUSKA
US 19 BY-P AND 23 BY-P BRDG.5 SW OF TOWN
11EPALES 2111204
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	11 00		0.550	0.440	0.126	0.005K	0.030
73/04/15	12 15		0.440	0.170	0.032	0.010	0.042
73/05/13	09 45		0.294	0.220	0.014	0.005K	0.025
73/05/27	09 45		0.300	0.380	0.028	0.005K	0.040
73/07/01	12 00		0.370	0.100K	0.005K	0.008	0.030
73/07/29	11 30		0.630	1.300	0.075	0.011	0.055
73/10/14	10 00		0.357	0.650	0.056	0.012	0.060
73/11/10	11 00		0.350	0.150	0.028	0.016	0.050
73/12/09	11 45		0.352	0.400	0.040	0.008	0.030
74/01/06	11 15		0.640	0.500	0.048	0.012	0.040
74/01/20	10 30		0.510	0.700	0.056	0.008	0.020
74/02/10	09 30		0.528	0.200	0.025	0.015	0.050
74/02/24	09 45		0.500	0.200	0.020	0.005K	0.035

K VALUE KNOWN TO BE
LESS THAN INDICATED

STREET DETAIL DATA 73/01/13

3709R1 LS3709R1
35 31 00.0 083 58 30.0
UNNAMED STREAM
37 7.5 CLYDE
1/LAKE JUNALUSKA
RD BRDG SE EDGE GOLF COURSEFAIRWAY HILLS
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT K JEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	10 50		1.360	0.230	0.120	0.007	0.050
73/04/15	12 10		1.240	0.210	0.100	0.017	0.040
73/05/13	10 00		1.140	1.100	0.048	0.014	0.030
73/05/27	10 00		1.120	0.260	0.056	0.011	0.042
73/07/01	11 00		1.220	0.600	0.044	0.010	0.025
73/07/29	11 00		1.220	0.260	0.070	0.018	0.050
73/10/14	09 00		1.100		0.084	0.017	
73/11/10	10 30		1.120	0.100K	0.020	0.012	0.012
73/12/09	09 30		1.400	0.100K	0.044	0.012	0.025
74/01/06	10 20		1.760	0.500	0.064	0.012	0.035
74/01/20	10 05		1.340	0.100K	0.044	0.008	0.012
74/02/10	10 00		1.500	1.300	0.105	0.010	0.030
74/02/24	09 30		1.520	0.200	0.040	0.010	0.045

K VALUE KNOWN TO BE
LESS THAN INDICATED

START PERIOD OF RECORD 73/03/25

3709C1 LS3709C1
35 31 30.0 083 59 00.0
FACTORY BRANCH
37 7.5 CLYDE
T/LAKE JUNALUSKA
HWY 19 BRDG .2 MI UPSTREAM FROM W END LK
11FMALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/03/25	10 30		0.960	0.200	0.063	0.007	0.045
73/04/15	11 45		0.810	0.350	0.078	0.011	0.045
73/05/13	10 15		0.620	0.320	0.063	0.015	0.065
73/05/27	10 30		0.600	0.330	0.064	0.009	0.055
73/07/01	11 30		0.630	1.800	0.105	0.032	0.120
73/07/29	10 30		0.660	0.910	0.063	0.015	0.070
73/10/14	08 20		0.700	1.450	0.180	0.017	0.055
73/11/10	10 30		0.720	0.300	0.068	0.015	0.040
73/12/09	10 30		0.924	0.100	0.052	0.012	0.040
74/01/06	09 45		1.260	0.200	0.055	0.010	0.045
74/01/20	09 10		0.940	0.400	0.052	0.008	0.030
74/02/10	10 30		1.010	1.200	0.105	0.010	0.050
74/02/24	09 15		1.010	0.200	0.030	0.005K	0.050

K VALUE KNOWN TO BE
LESS THAN INDICATED